Night Vision

Introduction

Air crewmembers rely more on sight than all other senses to orient themselves during flight. The ability to identify and manage the effects of visual limitations during night flight will greatly assist all air crewmembers to reduce the risks involved.

Many aviation missions are conducted at night. Therefore it is vital that a flight surgeon understand the physiology of night vision, depth perception, the affects of night vision devices, and night vision limitations.

After completing this lesson…

You will be able to:

- Manage the effects of visual limitations during night flight.
- Identify the functions of the rod cells during night flight.
- Identify the different types of vision used while viewing during decreased ambient light conditions.
- List the factors that affect dark adaptation.
- Recognize limitations of night vision.
- List the methods to protect visual acuity from night flight hazards and limitations.
- Identify the effects of the self-imposed stresses.

You will be able to discuss:

- The physiological effects of night vision devices (NVDs)
- The proper night viewing (scanning) techniques.

Vision Types

Types of vision used during decreased ambient light conditions:

- Mesopic vision
- Scotopic vision

What is Mesopic vision?

- Used during dawn and dusk

What is Scotopic vision?

- Night vision (partial moon and

lighting conditions and full moonlight time periods.
- Parafoveal region, a mixture of cones and rods, becomes the primary source of vision.
- Visual acuity and color perception is limited due to the decreased number of cones, and limited quantity of rods in the parafoveal region. Mesopic viewing period is considered the most dangerous period for viewing and depth perception.

starlight conditions).
- Mostly peripheral vision (mostly rods).
- Acuity degraded to 20/200. Silhouette recognition is degraded and color perception is lost. You can identify shades of black, gray, and white.
- Using off-center viewing and 10º circular overlap scanning techniques are necessary to compensate for the night blind spot.

Dark Adaptation

Factors affecting dark adaptation:

Photosensitivity of the eye

- Cone cells pick up certain colors by activating iodopsin, the photopigment molecule that responds to different colors (wavelengths) of light. Individual cone cells are sensitive to different colors: red, blue, yellow, or green.
- Rod cells are activated by rhodopsin (visual purple).
- Rhodopsin increases the rods effectiveness during dark viewing periods.

Bleaching affect of the photoreceptor cells

- Bleaching of the cones and rods occurs when eyes are unprotected and exposed to solar glare or other direct bright light.
- Cumulative unprotected exposure to bright light or solar glare can increase your dark adaptation time up to 3 to 5 hours, causing negative effects upon your night vision acuity.
- The duration of exposure to strobe light versus flare can have adverse

Poor nutrition and dietary habits

- Vitamin A deficiency hinders production of rhodopsin, which is required for the effectiveness of the rods during dark viewing periods or conditions.
- WARNING: Do not supplement Vitamin A in its pure form; it can have a toxic affect upon you physiologically. If supplementing for Vitamin A is necessary, a One a Day multi-vitamin is sufficient for the production of rhodopsin. Consult

- On an average it takes 30 to 45 minutes for your rods to be fully dark adapted to night vision.
- Your night vision will not get better with a longer dark adaptation period.

affects to your night vision acuity and dark adaptation.

your Flight Surgeon before taking Vitamin A supplements.

- Note: Consuming a well balanced diet that includes such foods as milk, cheese, carrots, green leafy vegetables, and organ meats (liver, heart etc.), will provide sufficient amounts of Vitamin A that is required for the production of rhodopsin.

Limitations of night vision

Depth perception

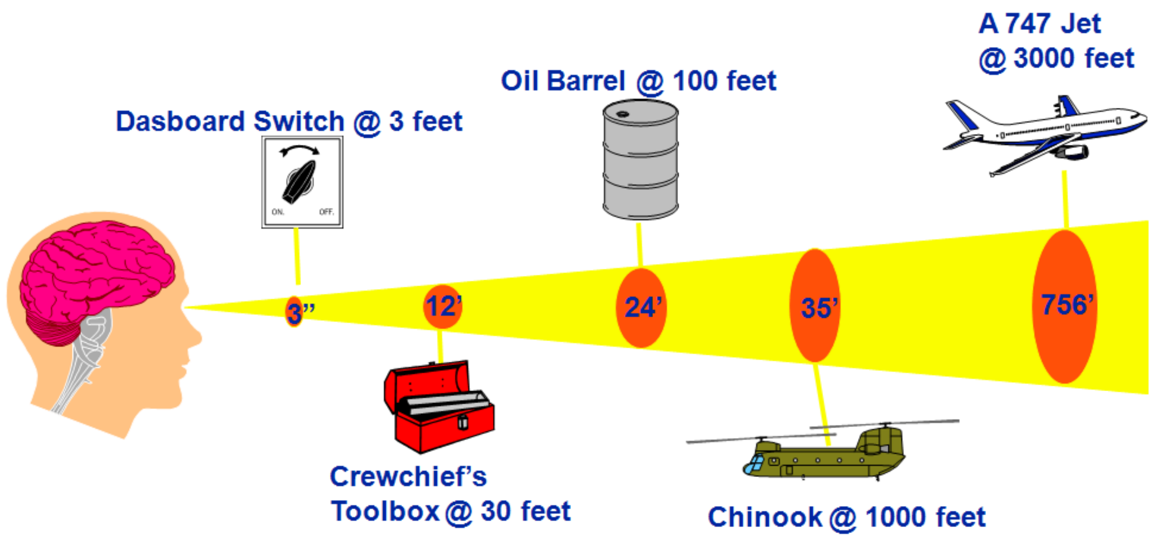
- You might believe or assume that you are at a higher altitude than you actually are (false interpretation or judgment of actual altitude related to poor depth perception).
- Use proper crew coordination to help determine your actual altitude.
- If mission allows, use your searchlight or landing light, which will help you determine your aircraft's position and altitude in regard to the ground or objects below you.

Visual acuity

- Visual acuity is, at its best, (20/20) during the mesopic period. Visual acuity during scotopic periods degrades to 20/200 or worse.
- Loss of degraded image sharpness and clarity.
- **NOTE:** Performing preflight mission planning with a complete crew is essential for night flight operations. Identifying published hazards on the map in relation to your flight route, noting their location and altitudes will greatly assist in the safe completion of such flights.
- **NOTE:** When possible, perform day reconnaissance flights to prepare for night flight operations. Identify and note the locations and altitudes of all unpublished obstacles and hazards. Disseminate this information to your crew and flight operations to update unit maps.

Night blind spot

- The night blind spot increases in size with distance.



- Proper scanning techniques must be employed to avoid hazards. See TC 3-04.93 for these techniques.

Proper night viewing (scanning) techniques:

Scanning

- Stop-turn-stop-turn motion scanning technique should be used. At each stop, scan an area approximately 30° wide. This viewing angle covers an area approximately 250 meters wide at a distance of 500 meters. The duration of each stop is based on the degree of detail that is required, but no stop should last longer than two to three seconds to prevent the rhodopsin from bleaching out the image.
- 10° circular overlap viewing should be utilized when moving from one viewing point to the next. Crewmembers should overlap the

Off-center viewing

- Can compensate for the night blind spot.
- View an object by focusing 10° above, below, or to either side of the object you are viewing in order to maintain visual reference of the object, but will not bleach it out and lose sight it.
- 10° circular overlap and off-center viewing are used in combination for unaided night

previous field of view by 10°.

Dark adaptation period

- Using goggles with red lenses while in an artificially lighted area will assist in decrease the average amount of time necessary to properly dark-adapt.
- Unprotected exposure to bright light or solar glare during day flights, night flights, and crew rest adversely affects night visual acuity and dark adaptation of the rod cells. Normally it takes 3 to 5 minutes to regain full dark adaptation after an unprotected exposure to bright light. The time that it takes to readapt can be lengthened by poor night vision preparation, decreased levels of rhodopsin, and multiple light exposures during flight.
- Blue wavelength light can have adverse affects upon night visual acuity, dark adaptation, and causes the onset of night myopia (nearsightedness) during flight. This can occur if the console lighting intensity is set to high. Operating console lighting and, if applicable, rear cargo area overhead light (blue or white) at high levels of intensity during extended flight time will bleach out the rhodopsin.
- Set console lighting intensity high enough that the pilot can read the information provided by the instruments without having to stare in order to gain the information. Crewmembers in the back of the aircraft will inform pilots up front before operating rear compartment lights. Crewmembers should use the lowest possible light intensity to perform task and not allow the light to bleach out the other crewmembers rhodopsin.
- Dial down the intensity of the console lighting during the flight, as the crew becomes dark-adapted less lighting will be needed.

Loss of or degraded color vision

- Color perception will be degraded or lost due to the lack of cone cell stimulation. Obstacles might not be seen or identified as rapidly as they would be during the day.
- Color perception will be limited to shades of gray, black, and white. This only intensifies your visual limitations during night unaided flying.
- Rod cells are used primarily at night to identify the outline of obstacles (silhouette recognition), which will assist you in determining their shapes and sizes.

Night myopia

- Caused by blue light wavelengths prevailing in the visible spectrum. Because of this, slightly nearsighted (myopic) individuals will experience visual difficulty at night when using blue-green lighting.
- Image sharpness decreases as pupil diameter increases.
- These factors combine to make vision unacceptably blurred in individuals with mild refractive errors. This becomes important when aircrew members are relying on terrain features during night unaided flights. Special corrective lenses can be prescribed to correct night myopia.

  NOTE: The visual system is the most reliable of the senses, but some illusions can result from a misinterpretation of what is seen. As visual information decreases, the probability of spatial disorientation increases. Reduced visual references can cause several visual illusions.

Visual Cues (binocular and monocular)

- Harder to distinguish under decreased ambient light conditions. Decreased light causes aircrew members to stare at objects or terrain features longer than they would in brighter light. Misinterpreting what is viewed is often caused by decreased ambient light.
- Binocular cues depend on the slightly different viewing angle each eye has of an object. Binocular perception is of value only when the object is close enough for a perceptible difference in the viewing angle each eye. Distances are usually so great in the flight environment that these cues are of little value, especially when seen in dark conditions. Binocular cues operate on more of a subconscious level than monocular cues do. Study and training will not greatly improve them.
- Monocular cues are derived from experience and are subject to interpretation. Monocular cues can help identify possible hazards, including manmade structures, terrain, and your altitude and position in reference to the ground.

NOTE: Proper crew coordination and communication combined with a detailed day reconnaissance flight and map reconnaissance before night unaided flight will improve flight performance under darkened conditions.

Visual Cues

Geometric Perspective	**Retinal Image Size**	**Aerial Perspective**	**Motion parallax**
Use the acronym LAV: • **L**inear perspective.	Use the acronym KITO: • **K**nown size of objects.	Use the clarity of an object or by the shadow that is cast by an object to determine its	One of the most important cues to depth perception is the apparent, relative motion of

• **A**pparent foreshortening appears elliptical (narrow). • **V**ertical position in the field.	• **I**ncreasing or decreasing size of objects. • **T**errestrial association. • **O**verlapping contours or interposition of objects.	size and distance Objects are seen less distinctly and appear to be at greater distance than they actually are when viewed through haze, smoke, or fog is. An object is seen more distinctly and appears to be closer than it actually is in unrestricted atmospheric conditions. Sharpness and clarity of details or texture are lost or are less apparent with distance.	stationary objects as viewed by a moving observer. Near objects appear to move past or opposite the landscape. Far objects seem to move in the direction of motion or remain fixed. The rate of apparent movement depends on the distance the observer is from the object. Rapidly moving objects are judged to be near while slow moving objects are judged to be distant.

Geometric Perspective

Use the acronym **LAV**:

- **L**inear perspective. Parallel lines such as railroad tracks tend to converge as distance from the observer increases
- **A**pparent foreshortening appears elliptical (narrow) at lower altitudes. Like a round pond looks from a lower altitude. If the mission permits, pilots should gain altitude an decrease distance from the viewing area to compensate for this perspective.
- **V**ertical position in the field. Objects or terrain features at greater distances from the observer appear higher on the horizon than those closer to the observer.

Retinal Image Size

Use the acronym **KITO**:

- **K**nown size of objects. The nearer an object is to the observer, the larger its retinal image. By experience, the brain learns to estimate the distance of familiar objects by the size of their retinal image.
- **I**ncreasing or decreasing size of objects. If the retinal image of an object increases in size, the object is moving closer to the observer. If the

retinal image decreases, the object is moving further away. If the retinal image is constant, the object is at a
fixed distance.

• **T**errestrial association. Comparison of one object such as an airfield with another object of known size such as a helicopter
helps in determining the relative size and apparent distance of the object from the observer.

• **O**verlapping contours or interposition of objects. When objects overlap, the overlapped object is further away.

Aerial Perspective

An object's clarity or shadow that is cast can be used to determine its size and distance. Objects are seen less distinctly and appear to be at greater distance than they actually are when viewed through haze, smoke, or fog.
An object is seen more distinctly and appears to be closer than it actually is in unrestricted atmospheric conditions. Sharpness and clarity of details or texture are lost or are less apparent with distance.

Motion Parallax

One of the most important cues to depth perception is the apparent, relative motion of stationary objects as viewed by a moving observer. Near objects appear to move past or opposite the landscape. Far objects seem to move in the direction of motion or remain fixed. The rate of apparent movement depends on the distance the observer is from the object. Rapidly moving objects are judged to be near while slow moving objects are judged to be distant.

Protecting Visual Acuity

What are methods of protecting visual acuity from night flight hazards and limitations?

Basic protective methods

- Lower your clear visor during night unaided flight.
- Adjust cockpit lighting to lowest readable level.
- Lower the intensity of your aircraft's interior and exterior lighting if mission permits.
- Close or cover one eye briefly when unexpectedly exposed to a bright light when flying at night unaided.

NOTE: Each eye dark-adapts independently. By closing or covering one eye you will retain some of your night visual acuity in the covered eye or closed eye.

Supplemental oxygen

- Use supplemental oxygen if available when flying above 4,000 feet.
  NOTE: The onset of hypoxia had affects upon your night vision that might occur as low as 4,000 feet in altitude.
- Utilize searchlight or landing light (if mission permits).
- Use short ordinance burst (flash of bright light or tracer).

Nutrition:

- Consume a balanced diet (take a "One a Day" vitamin supplement—do not take pure vitamin A)

Hydration:

- Consume water; eyes need abundant oxygen to function properly.
- Dehydration can cause blurred vision and staring.
- Dehydration causes a decrease in fluid circulation, which reduces oxygen levels in the bloodstream.

Specific Things to avoid:
Lasers

- Lasers are utilized widespread throughout the United States armed services and foreign militaries. The use of lasers as a weapon system has and will continue to occur by our opposing forces. Most lasers that generate enough power (intensity) will not be seen by the naked eye. Even when flying under aided conditions laser, exposure is a possibility.
- Use of B-LPS (laser specific protective visors and goggles).
- Gain distance from laser source and get out of the laser path.
- Lasers injuries are primarily associated with your eyes, and can occur from a considerable distance. Distance is the best protection, but if that is not possible the use of laser specific protective goggles and visors B-LPS (Ballistic and Laser Protective Eyewear) will provide protection.
- During your pre-mission planning you should attempt to identify what the types of lasers, where, and when you might possibly be exposed to during your flight. Identifying the specific type of laser will assist you in obtaining the correct laser protective goggle or visors that are required prior to your flight.
- Unprotected laser exposure impairs night vision acuity.

Nerve Agents

- Nerve agent hazards are always a possibility and can be present during night operations.

- The timely manner in which you identify the physiological effects of nerve agents during night operations can determine the success and survivability of your crew.
- When direct contact occurs, minute amounts can cause miosis, constriction of the pupils. Pupils will not dilate (enlarge) in low ambient light as they would normally. Chemical alarms might not detect presence of nerve agents.
- Exposure time required to cause miosis depends on the agent concentration and the cumulative effects of repeated exposure.
- Symptoms range from minimal to severe depending on agent’s concentration and duration of exposure.
- Severe miosis can persist for 48 hours or longer after onset of exposure.
- Complete recovery can take up to 20 days or longer.
- There will be some loss of night vision among personnel exposed. Refer all exposed personnel to the flight surgeon immediately before performing flight duties or aircraft maintenance.

Bright Light

- Avoid exposure to bright light during night unaided flight.
- Avoid brightly lit areas.
- Avoid looking at aerial and ground flares, spotlights, vehicle headlights, searchlights, and beacon lights.
- Protective measures consist of turning your head away from the source, covering or closing one eye, transfer of the controls if copilot is available and not experiencing the same negative effects, or change aircraft heading if mission permits.

Next, let's look at some self-imposed stresses…

Self-imposed Stresses

What are the effects of the self-imposed stresses on night vision?

Drugs	**Exhaustion**	**Alcohol**	**Tobacco**	**Hypoglycemia and nutritional deficiency**
Some drugs cause isotopic hypoxia, the saturation of tissue cells with alcohol or drugs, which	Ineffective night vision viewing techniques (related to staring instead of scanning). Altered	Detrimental effect on scanning techniques (tendency to stare at objects) perception, reaction time,	Smoking causes hypemic hypoxia, which is the greatest threat to night vision.	Poor dieting can lead to Vitamin A deficiency, which hinders production of rhodopsin. Consumption

interferes with the decreases tissue perfusion of oxygen.	concentration, awareness, attentiveness, and increased drowsiness reduce air crewmembers' ability to interpret visual cues	coordination, judgment and decision-making. Isotopic hypoxia: The consumption of one ounce of alcohol places an individual at 2,000 feet physiologically. **NOTE:** AR 40-8 states that crewmembers will not perform flight duties within 12 hours of consuming an alcoholic beverage and then until there are no residual effects remaining.	Effects of tobacco: decreased night vision viewing capability (an average of 20 % at sea level) The physiologic effect at ground level is the same as flying at 5,000 feet. **Hypemic hypoxia:** a reduction of the oxygen carrying capability of red blood cells. Carbon monoxide binds with the hemoglobin, not allowing or severely decreasing the amount of oxygen allowed to bind with the hemoglobin.	of a balanced diet to produce the chemical rhodopsin should consist of the following foods: eggs, butter, cheese, liver, carrots, and most green leafy vegetables

Night Vision Devices (NVDs)

Physiological effects:

- Decreased ability to perceive accurate depth perception
- Decreased distance estimation
- Decreased degree of contrast
- No color vision
- Discoloration of objects (chromatic)
- No blind spot
- No dark adaptation required
- Higher visual acuity than unaided night vision (approximately 20/40)

Chromatic adaptation:

- Discoloration of objects viewed with the unaided eye after viewing through NVDs (ANVIS) for an extended time.
- This is a normal physiological response. It causes no discomfort and will disappear or subside within 3-5 minutes, on average.
- It will take 3-5 minutes to regain your full dark adaptation and night vision acuity.

Spatial disorientation:

- Aircraft bank greater than 30°.
- Use a scanning technique consisting of rapid head movements.
- Rapid head movement can cause spatial disorientation.
- Unfamiliar perception related to lack of NVG experience

Night Vision Device Tips

Tips for using night vision devices (NVDs)

Scanning

- Must use scanning techniques more with NVDs than unaided night vision.
- NVDs have a narrow field of vision (only 40° with some older NVDs)
- Do not "over-scan" or move your head too rapidly. Rapid head or eye movement and fixation decrease the integrating capability of dark-adapted eyes. A steady fixation lasting .5 second to 1 second achieves maximum sensitivity.

- Objects viewed longer than 2 to 3 seconds tend to bleach out and become one solid, invisible tone, resulting in a potentially unsafe operating condition.
- Crewmembers must be aware of this phenomenon and avoid viewing objects longer than 2 to 3 seconds.

Increase crew coordination during NVD-aided flight

- Plan for positive three way transfer of controls between crew members when transitioning from unaided to NVD-aided flight; for example, "I have the controls," "You have the controls," "I have the controls."
- Let other crewmembers know when you will be “looking in” (studying a map or fixed on another object for a long time), instead of scanning the sky for hazards